ELECTRONIC SYSTEM OF FLOOD MONITORING AND VISUALIZATION

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Flood-protection is especially important for territories, which may become a subject of catastrophically influence of high waters. Carrying out anti-flood actions results in reduction of actual damages caused by flooding, however it demands significant expenses and exploitation charges. As it is impossible to completely exclude flooding, the priority is to adapt economic activities as much as possible to probable extreme conditions and thus minimize the damage. Electronic systems of flood monitoring are developed in bounds of that strategy nowadays for high-risk areas. Here we present one of such systems – the distributed hardware and software complex of flood monitoring and prediction, which is moving to the end of its development cycle for rivers of Byelorussian Polesye but uses rather universal approaches and software parts and is not highly special to spoken above territories.

Developed complex of distributed hardware and software includes the united information center (UIC), which processes data streams from the distributed network of autonomous hydrological devices (AHD), placed in control points of the river basin.

The query of data is transferred from AHDs to UIC by means of GSM-network. The UIC functions as calculating server: it collects the information through a cell communications channel, and shows the degree of river bottomland flooding. Calculations may be based not only on data from AHDs but also on discussed earlier statistical data of hydrological measurements, mathematical models of watercourses movement and 3D maps of the terrain (Volchak et al., 2007).

AHD construction includes (Kozak et al., 2008) ultrasonic sensors (UPTs), a micro-controller, embeddable GSM-modem, power supply and signal amplification systems. Three UPTs are used in the AHD: one operates in combined radiation and receive mode as a depth meter; information about water level is acquired from a delay between the radiated signal and its reflection from the water free surface. Measurement of flow speed uses radiating and receiving UPTs and can be carried out by one of two methods. Firstly, speed of water flow can be determined on Doppler shift of frequency of the accepted signal concerning frequency a radiated one. Secondly, time delays can be also registered when sound spreads alongside the water flow direction and opposite to it.

Primary processing of UPTs response as far as all necessary operation modes switching and calculations are done by Texas Instruments MSP430 microcontroller. Measurements can be carried out along with specified schedule or initiated by the command from UIC for the operational control. AHD is powered by the industrial lithium battery which allows several months of usage, depending on the sessions a GSM-modem, which is the main electric charge of a system. Using solar cell extends the device unattended operation up to 1-2 years.

AHD software is combined of two parts: the MSP430 program stored on a flash-memory and the calibration program which runs on a personal computer to configure AHD (base speed of a liquid, measurements schedule, duration of the feed pulse, time corrections, data transfer parameters, indication modes, etc.).

Due to developed construction AHD can function autonomously for a long time, carrying out planned measurements having no connection with UIC. Communications protocol allows to initiate measurement manually and to read the UPTs flash-memory for previously carried measurements. System of commands includes reading/setting date and time, performing depth/speed measurement or getting previously saved data achieved in a stack-like structure, as far as reading/writing time period for autonomous measurements.

Software of UIC includes the interfacing module with AHDs and also forecast and visualization modules. Hydrological database keeps received measurements values and also may be manually filled with data from non-automated hydroposts.

Artificial neural networks were chosen while considering the mathematical basis for near forecast in UIC (Volchak et al., 2009). Sets of hydrographers representing measurements of previous years were used as input data at training network for forecasts in addition to real-time AHD data. A multilayer perceptron was used as the forecasting network. Acceptable accuracy was mainly achieved at 5 predicted values (daily periodicity of measurements was used in accumulated statistics). Effectiveness of near forecast, received with trained neural network, also makes it purposeful in some cases to use a superposition of data from neural-based method and ones of statistics-based forecasts while estimating the flood situation. Particularly, developed system uses mechanism of sliding frame in statistical data array as the realization of analogy method for extended forecasts.

Flood visualization is carried out on the basis of digital elevation maps and the information about water level in control points, where AHDs are placed. Rendering the segments of the triangulated terrain model is asynchronously done in OpenGL graphics with LibMINI library. Segments are loaded into memory at their appearance in the visible area. Being the function of the terrain complexity, mesh density is increased near the coastline.

The source for the triangulated terrain model is a 2D isoline diagram. Original map data are taken from raster digitized maps, vectorized by the semi-automated method. Level of the water mirror is semilinearly approximated on the basis of AHDs data and/or manually submitted level marks for a control points in the river axis. Then 3D inclined plane roughly circumscribing water mirror are plotted, and their crossing with terrain surface is determined to find out the flood water zone and to render its area (the water surface incline angle is supposed to have no changes between two control points).

Water surface can also be visualized on hydroposts statistics from previous years, previously entered into UIC, and, finally, on forecast data.

References

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